Spatially Balanced Sampling

Application to environmental surveys

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Introduction

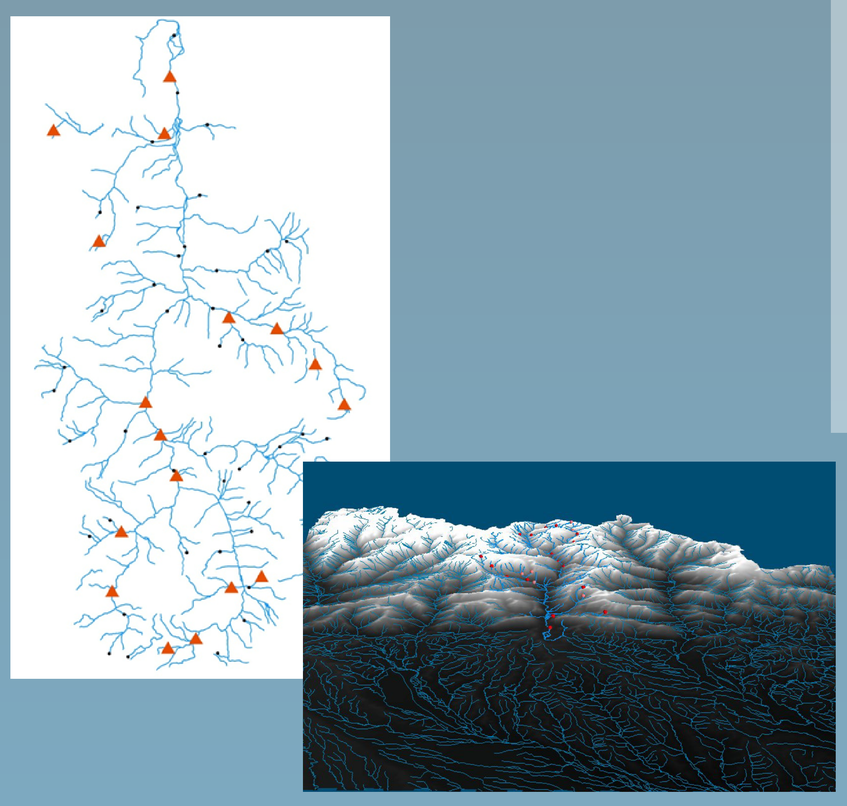
Access to quality information on the status of natural systems is the foundation of good environmental management.

Field surveys that collect data from sites spread across the landscape will be more informative than designs where sites are clustered.

The class of surveys that have this feature of spread is called spatially balanced survey designs.

Generalized Random Tessellation Stratified sampling

Generalized Random Tessellation Stratified sampling (Stevens and Olsen 2004) is one of the most widely used methods to achieve a spatially balanced sample. The sample is balanced, with neither any one area being over-represented with high sample intensity nor under-represented with low sample intensity.

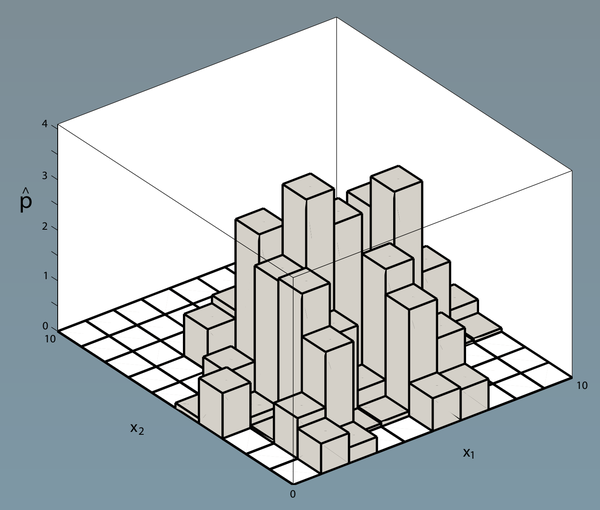


Courtesy of Frank D'Amico

Balanced Acceptance Sampling

Balanced acceptance sampling, BAS, (Robertson et al. 2013) is a new spatially balanced design. This method uses the Halton sequence, a quasi-random number sequence and is more computationally efficient than the GRTS algorithm. We observed some advantages in the level of balance with BAS over GRTS.

A feature of BAS (and some other spatially balanced designs) is that if more sites are added over time, the survey will stay balanced. Or, if a site can not be visited (e.g., access is denied), an alternative site can be added. Systematic surveys are constrained to having a fixed grid of site locations. Any change in sample size or site locations can mean the survey is not balanced.



BAS continued

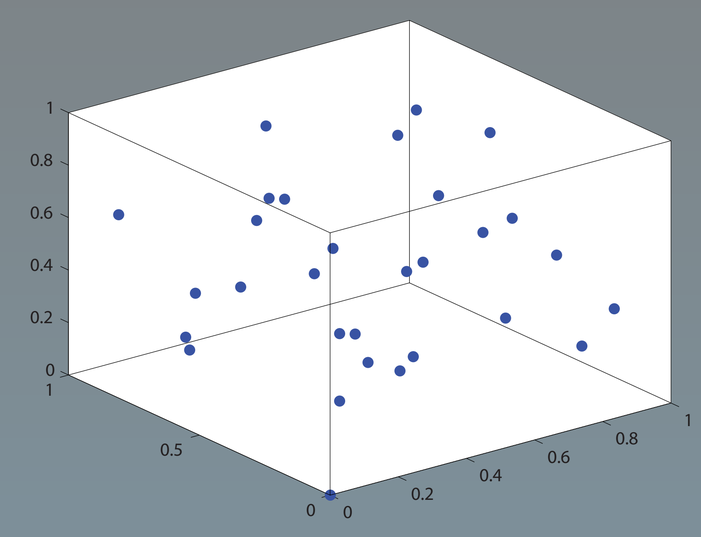
In two-dimension space, Halton points are used to generate the geo-referenced locations of the sample units.

Acceptance/rejection sampling is used to select sample units. If a generated sample point is beyond the edge of the sample space the sample unit is rejected, otherwise it is accepted.

First order inclusion probabilities can be calculated, or estimated, for the design for use in estimating the sample variance.

BAS in more than 2 dimensions

One appealing feature of BAS is that surveys can be balanced in more then 2 dimensions. For example with designs where there are repeat surveys over time the interval between sites being measured can be random, giving balance in both time and space.

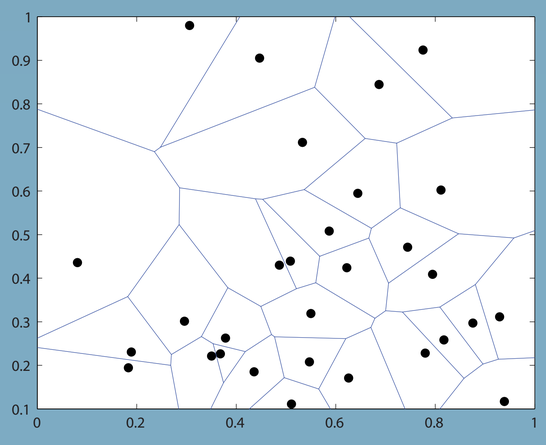


BAS in environmental surveys

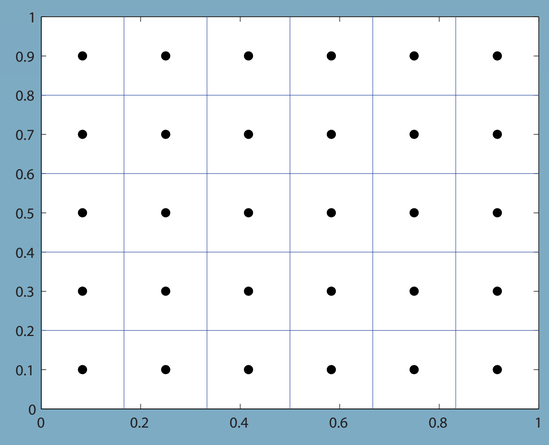
BAS can be used in both equal and unequal probability sampling. Unequal probability sampling is very common in environmental surveys.

Monitoring biological invasions often uses the concept of preferentially surveying sites considered to be at risk of invasions, or more vulnerable to threat.

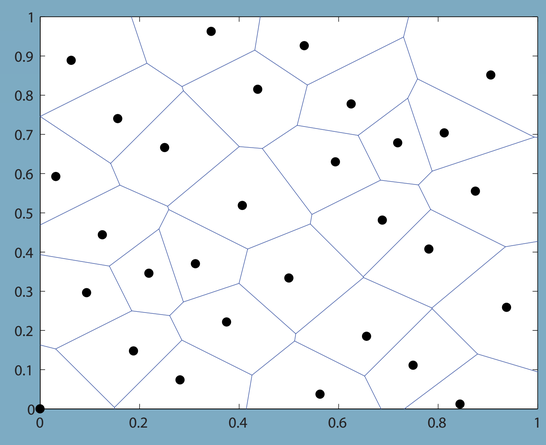
This feature of unequal probability of selection (thus resulting in a survey with spatial balance but unequal survey intensity) can be accommodated in BAS by having an inclusion probability dimension in the design.



Simple random sampling



Systematic sampling



Spatially balanced sampling

Robertson BL, Brown JA, McDonald T, Jaksons P. BAS: Balanced acceptance sampling of natural resources. Biometrics 2013; 69:776–784.
Stevens DL, Olsen AR. Spatially balanced sampling of natural resources. J Am Stat Assoc 2004; 99:262-278.
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